IPv6 Project Status

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Agenda

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Internet Protocol (IP) Background

IP Timeline

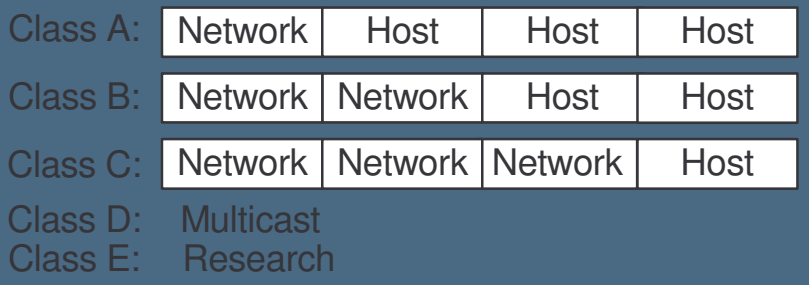
- 1958 - ARPA is formed by the US government.
- 1964 – RAND corp. proposes distributed communications network. [11]
- 1968 - ARPANET begins - 4 nodes at UCLA, SRI, UCSB, and U of Utah.
- 1974 – Vint Cerf and Bob Kahn establish TCP.
- 1981 – Current version of IP (v4) is released (RFC 791)
- 1983 – TCP/IP becomes core Internet protocol replacing NCP. [12]
- 1983 - The University of Wisconsin created Domain Name System (DNS). [12]
- 1995 – IETF specifies IPv6 (RFC 1883.)
- 1998 – Most current IPv6 RFC (2460) is released.
- 2000 – Internet2 implements tunneled IPv6 in its backbone (Abilene.)
- 2001 – MAX tunneled IPv6 to Abilene
- 2002 – Abilene NOC deploys native IPv6.
- 2002 – MAX establishes native IPv6 connection to Abilene.
- ***2002 – LHC/NLM establishes native IPv6 connection to MAX.***

IPv4 Overview

IPv4

- Internet Protocol version 4 (IPv4) has been in use for 20 years. [5]
- 32-bit hierarchical scheme

  Network and host portion.
- In theory - 2^32 or approximately 4.3 billion addresses.
- In practice only ~250 million addresses are available.[9]
- Classes A-C are assigned based on network size.



IPv4 – Addressing

- Hierarchical scheme.
  - Improves manageability of network.
  - Wasteful.
- To conserve IP addresses:
  - Classless Inter-domain Routing (CIDR) (See Supplement A for details)
    - Single IP address can be used to designate many unique IP addresses.
    - Reduces the size of routing tables and make more IP addresses available within organizations." [1]
  - Network Address Translation (NAT) - Allows use of a pool of IPs for external communication. [1]

Issues with IPv4

- Depletion of IP addresses.
- No integrated security at the IP level.
- No auto-configuration.
- Network Address Translation (NAT)
  - No IP transparency

    Blocks peer-to-peer communications (e.g., IP phones).
  - Increases complexity of network, harder to manage.

Issues with IPv4 (Cont.)

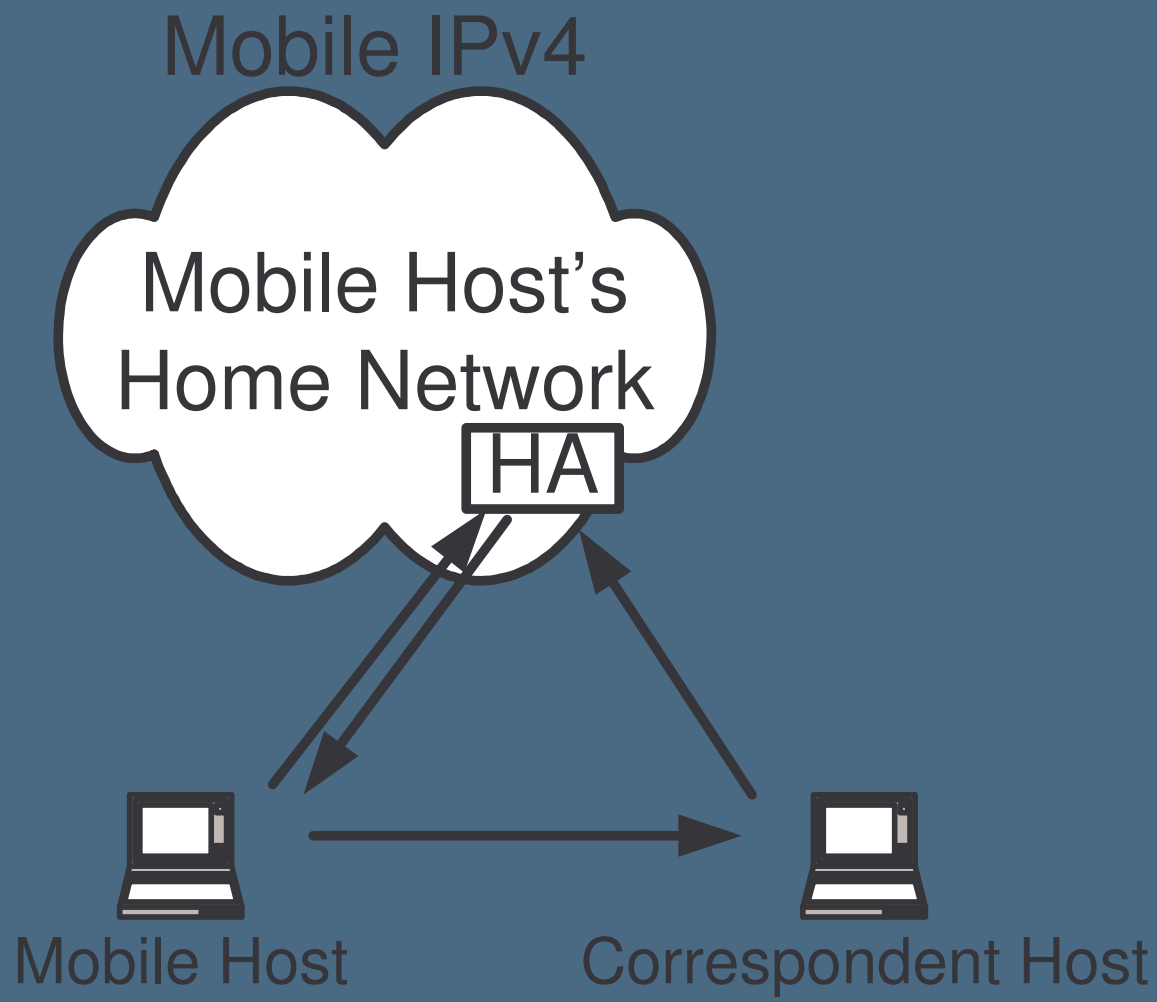
- Mobility
  - "Triangle routing" – More latency and bandwidth usage.
  - Uses statically configured mobility security associations, instead of IPSec.

http://www.6ants.net/doc/draft/draft-ietf-mobileip-ipv6-18.txt

  - Use of encapsulation for "all" mobile IP packet delivery (instead of routing header) more overhead.
  - Need "Foreign agents" (special routers).

All these issues will be exacerbated by 2005

1.17 billion Internet users worldwide. 62% will be wireless users. [24]


Mobile IPv4
Mobile Host's
Home Network
HA
Mobile Host
Correspondent Host

IPv6 Overview

Request For Comments 2460

1. According to RFC 2460 changes fall into the following categories:
    1. Expanded Addressing Capabilities
    2. Header Format Simplification
    3. Improved Support for Extensions and Options
    4. Flow Labeling Capability
    5. Authentication and Privacy Capabilities

IPv6 Capabilities/Features

- **Scalability**: 128-bit hierarchical addresses.
- **Faster routing:** Simplified headers.

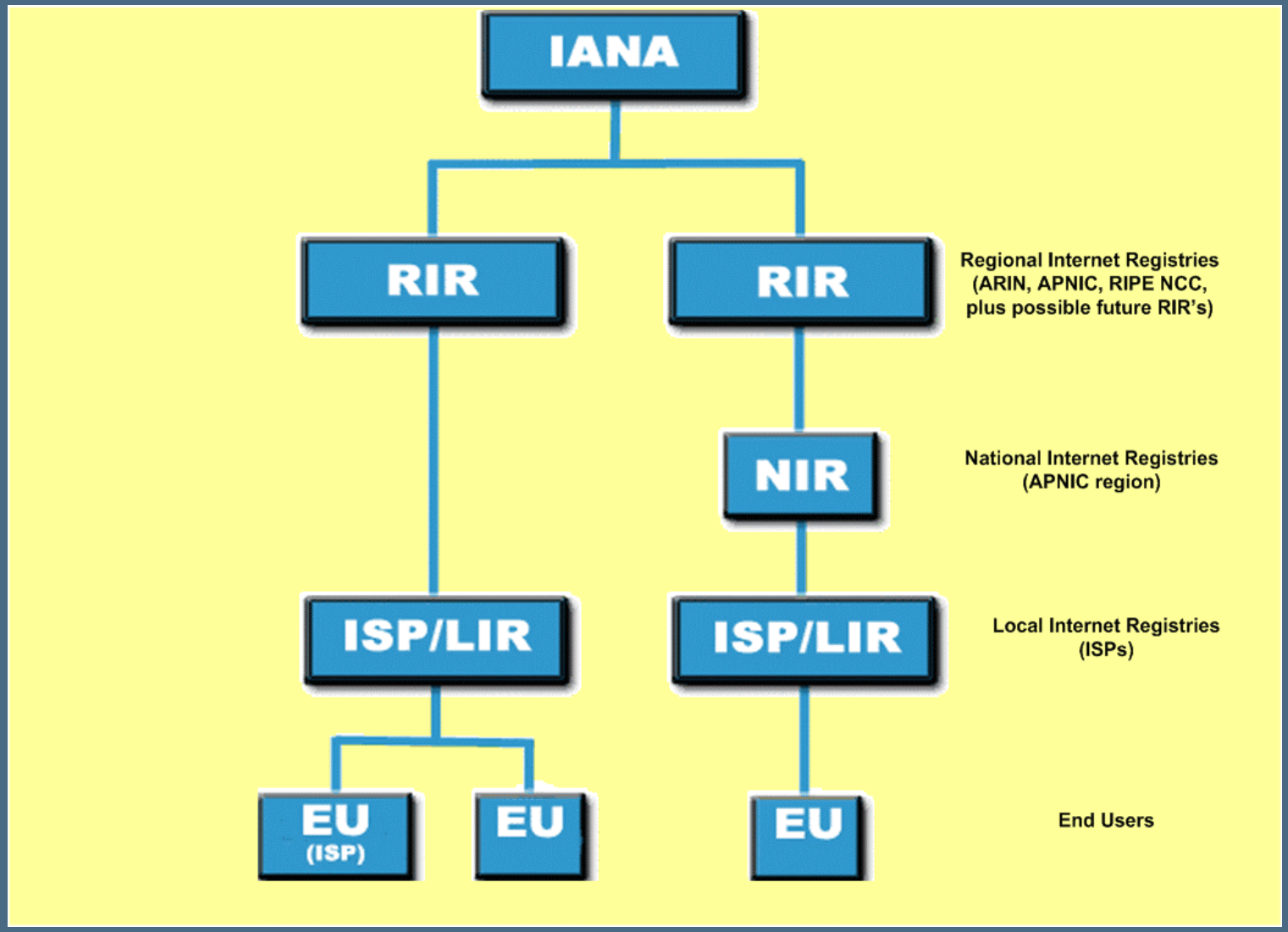
- **Flow label -** requests for special handling by routers

  traffic, such as video streams router can know which end-to-end flow a packet belongs to, and then find out the packet which belongs to real-time traffic.
- **IPsec** – Built-in security at the IP layer. Integrated authentication, integrity, and confidentiality.
- **Autoconfiguration** – (RFC 2462)
  - Stateless autoconfiguration – no manual conf. of hosts. Little, if any, conf of routers, no additional servers.
  - Stateful configuration –
- **Peer-to-peer applications/transparency – Online banking, medical records system sharing, Cafes with Internet Access.**
- **Easy renumbering – assignment of multiple addresses to same interface.**

Mobile IPv6

- **Integrated route optimization – Direct** routing from any correspondent node to any mobile node, avoiding "triangle routing." [19]
  - **Decreases latency and bandwidth needs.**
- **Special routers/"special agents" not needed. Mobile hosts use address auto-configuration and neighbor discovery features to operate in a network away from home.**
- **Uses IPSec.**

Hierarchical Structure for Managing IPv6 Addresses [14]

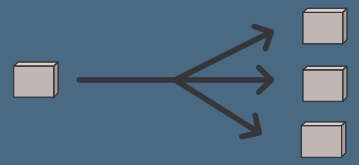


IPv6 Types of Addresses [6]

- Unicast – For one-to-one communication.

- Anycast – For one-to-nearest communication.

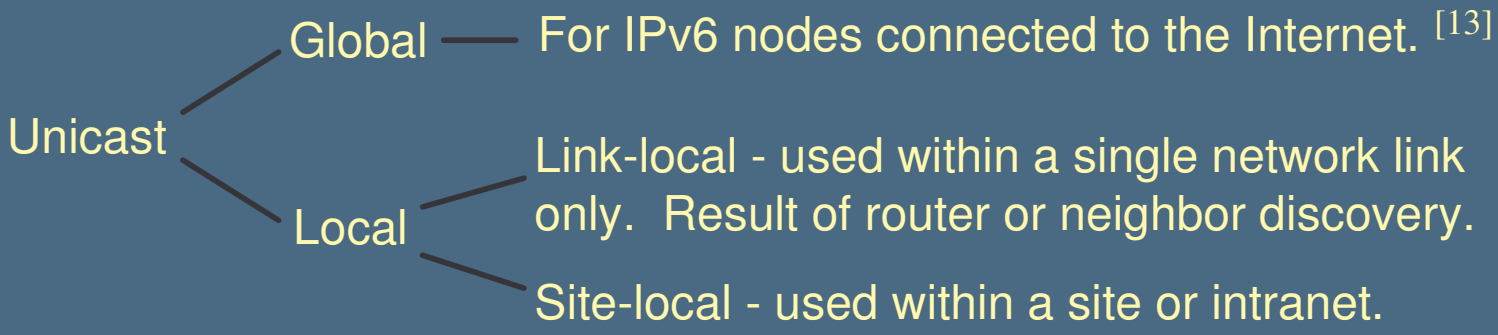
- Multicast – For one-to-many communication.



- No broadcast addresses. This function is superseded by multicast addresses.

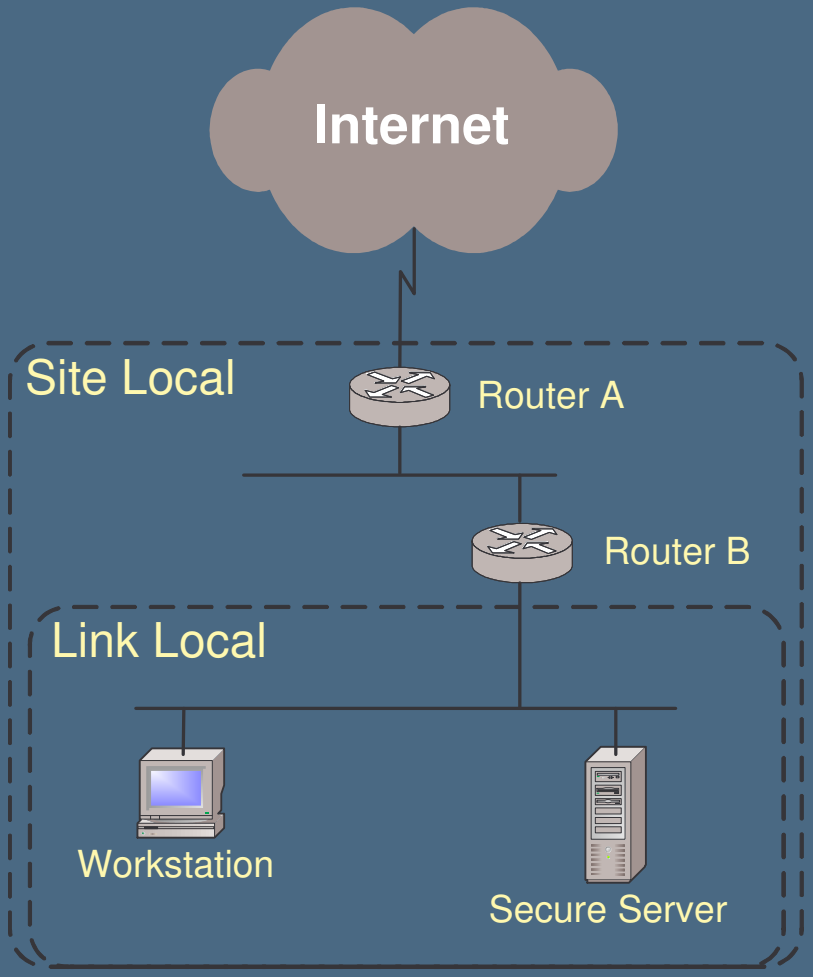
Address Scope

Unicast and multicast addresses support scoping.



Multicast - support 16 different types of scope, incl. Link, node, site, org., etc.

A Scoped Network [15]

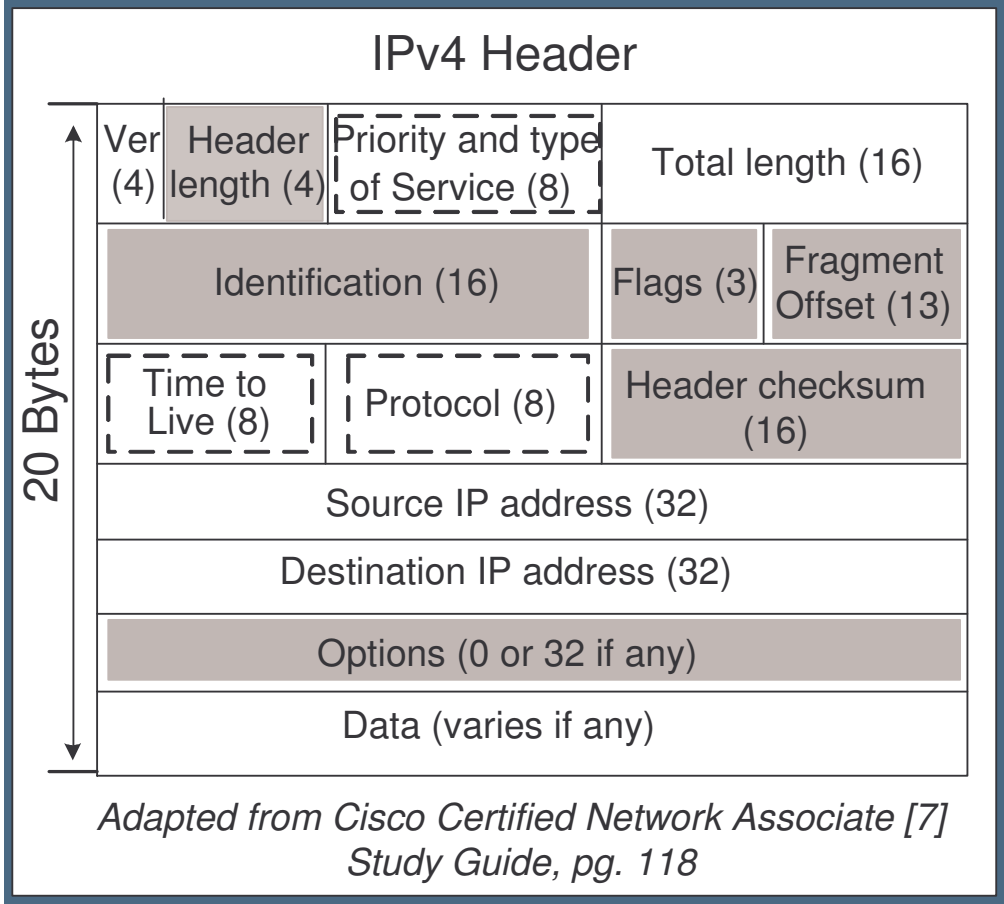


Source: The Unix Review [15]

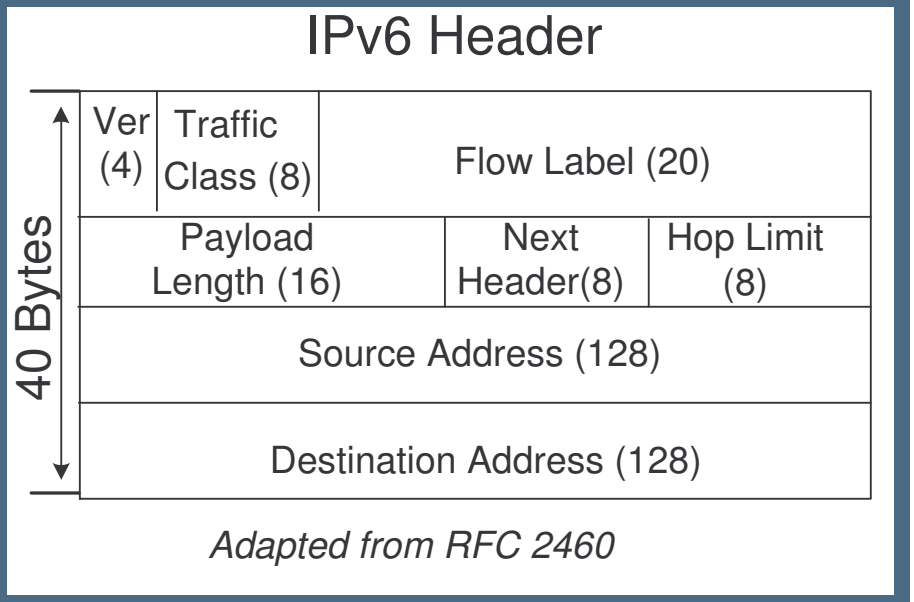
Text Representation of Addresses

- IPv6 addresses are written in hexadecimal.
  Eight 16-bit sets in each address, for example:
  2001:0468:0C06:0:0:0:0:0
- Leading zeroes on the left most position of each set can be removed
  2001:468:C06:0:0:0:0:0
- Addresses containing zeroes can be compressed.
  Address above can be 2001:468:C06::
  or 0:0:0:0:0:0:0:0 can be ::

Headers: IPv4 vs. IPv6



Adapted from Cisco Certified Network Associate [7] Study Guide, pg. 118

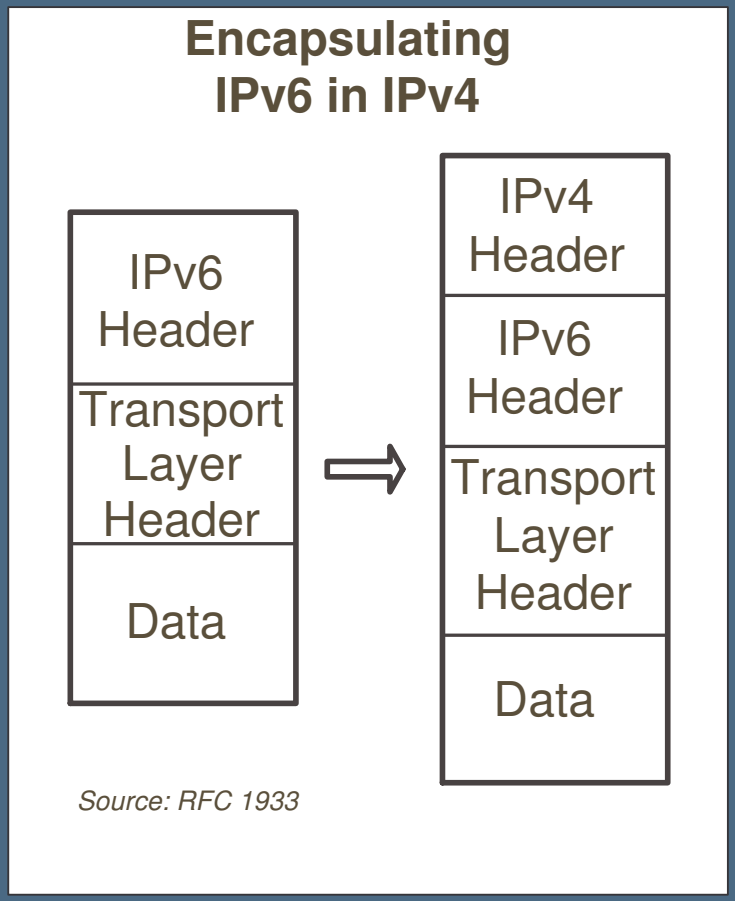


Adapted from RFC 2460

Two ways of implementing IPv6

Native connection – Between two IPv6 enabled networks.

Tunneling – Encapsulating IPv6 packets over an IPv4 infrastructure.



Software/Internet Applications Capable of Running over IPv6

- Operating systems:
  - Windows 2000, Windows XP, FreeBSD, NetBSD, OpenBSD, Sun Solaris 8, Mac OS X. [8] , some Linux distributions (to check status go to: http://www.bieringer.de/linux/IPv6/status/IPv6+Linux-status-distributions.html).
- Applications/Utilities:

  Mail, DNS (BIND 9) , Web server/browsers, FTP, Telnet, Ping6, tracert6, COLD (packet sniffer), IPFilter (firewall.) [20]

Vendors Supporting IPv6

Among others:

Alcatel – http://www.alcatel.com/

Cisco – http://www.cisco.com/warp/public/732/Tech/ipv6/

Extreme Networks – http://www.extremenetworks.com/

IBM – http://www.ibm.com/us/

Juniper – http://www.juniper.net/products/ipv6_overview.html

Microsoft - http://www.microsoft.com/windows.netserver/technologies/ipv6/default.mspx

Nokia - http://www.nokia.com/ipv6/index.html

Novell – http://www.novell.com/

Sun Microsystems – http://wwws.sun.com/software/solaris/ipv6/

Note to Developers

- Microsoft site on IPv6 Implementations (as of August 2002)

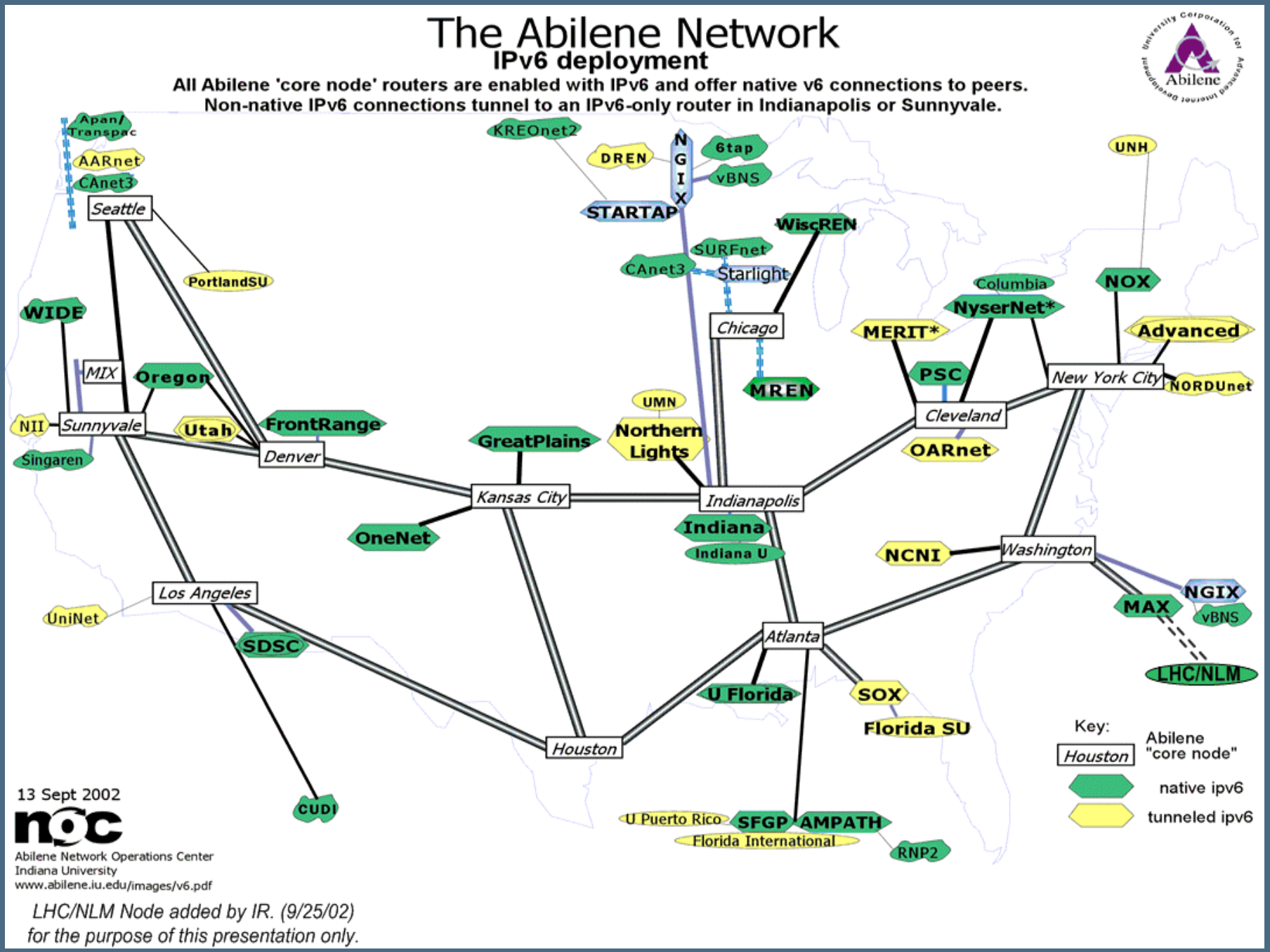
  http://www.microsoft.com/windows.netserver/technologies/ipv6/default.mspx#implementations

  - Windows .NET Server 2003 Family – RC1 Production-quality version of IPv6
  - Windows XP – provides developer-release version of IPv6. Recommended for creating sample configurations and porting your applications to run over IPv6. [13]
  - Windows CE .NET 4.1 – inc. production-quality support for IPv6 and IPv4/IPv6 mechanisms.

- **Adding IPv6 Capability to Windows Sockets Applications (while retaining IPv4 functionality.)**

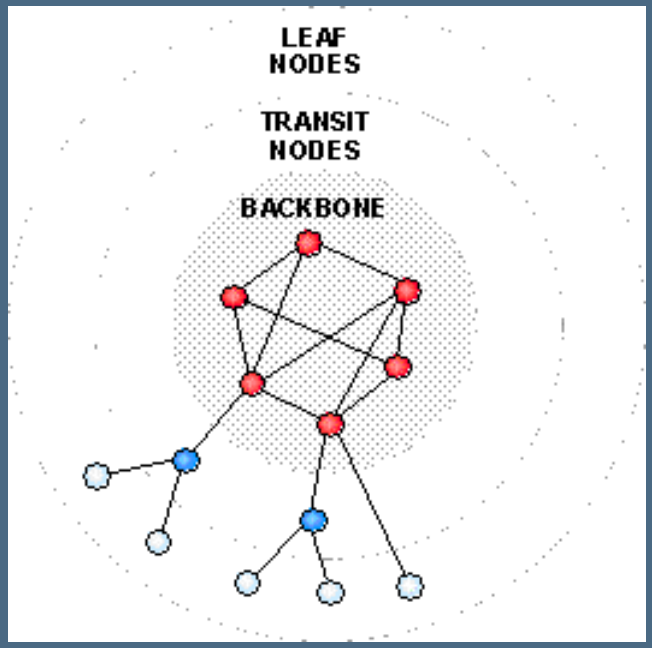
  http://www.microsoft.com/windows2000/technologies/communications/ipv6/ipv6winsok.asp

Global and Local IPv6 Deployment


The Abilene Network
IPv6 deployment
All Abilene 'core node' routers are enabled with IPv6 and offer native v6 connections to peers.
Non-native IPv6 connections tunnel to an IPv6-only router in Indianapolis or Sunnyvale.
Abilene
Apan/ Transpac
AARnet
CAnet3
Seattle
PortlandSU
WIDE
MIX
Oregon
NII
Sunnyvale
Singaren
Utah
FrontRange
Denver
KREOnet2
DREN
NGIX
6tap
vBNS
STARTAP
WiscREN
SURFnet
CAnet3
Starlight
Chicago
MREN
UMN
Northern Lights
GreatPlains
Kansas City
OneNet
Indianapolis
Indiana
Indiana U
UNH
Columbia
NyserNet*
MERIT*
NOX
Advanced
PSC
NORDUnet
New York City
Cleveland
OARnet
NCNI
Washington
NGIX
MAX
vBNS
LHC/NLM
UniNet
Los Angeles
SDSC
CUDI
Atlanta
U Florida
SOX
Florida SU
Houston
U Puerto Rico
SFGP
AMPATH
Florida International
RNP2
Key:
Houston
Abilene "core node"
native ipv6
tunneled ipv6
13 Sept 2002
noc
Abilene Network Operations Center
Indiana University
www.abilene.iu.edu/images/v6.pdf
LHC/NLM Node added by IR. (9/25/02)
for the purpose of this presentation only.

The 6Bone

- Global testbed network for IPv6.
- Started in March 1996.
- 59 countries with a total of 1161 sites.
- 185 sites in the U.S., incl. vBNS, Cisco, Juniper.
- Three level hierarchical network.



Source: inet Japan [21]

ISPs

- NTT Communications
  - In 2001, Japanese ISP was the first one to offer commercial IPv6 services.
  - Boasting the world's first commercial quality Asia-US-Europe IPv6 backbone. [17]
- Stealth Communications – based in New York

  http://www.stealth.net/ipv6.html

LHC- IPv6 Implementation Status

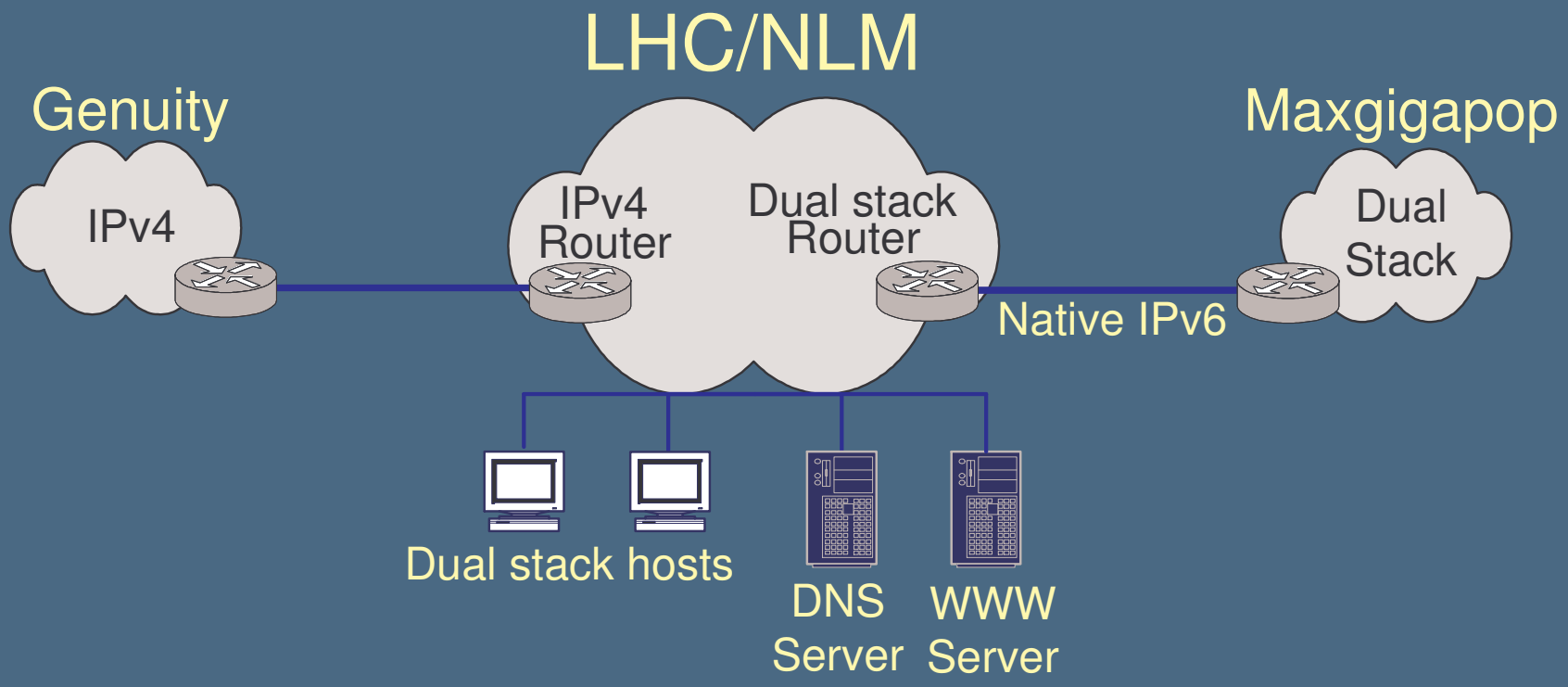
Completed items

- Address space allocated by Maxgigapop
  2001:0468:0C06::/48

To Do List

- Setup a DNS server capable of handling IPv6 addresses
- Decide on IPv6 addresses allocation plan
- Setup native IPv6 on our Juniper router
- Get native IPv6 connectivity from Maxgigapop
- Setup dual stack hosts - Linux or Windows 2000 box with IPv4 and IPv6

LHC Proposed IPv6 Network Design



NLM Research Program/NGI

- “NGI research program to develop innovative medical projects that demonstrate the application and use of NGI capabilities:
  - Quality of Service
  - Medical data privacy and security
  - Nomadic computing
  - Network management
  - Infrastructure technology for scientific collaboration “ [22]

IPv6 Benefits to NLM's NGI Program

1. What features of ipv6 pertain to NGI program expectations?

   QoS - flow label-better support for QoS, real-time applications (e.g. telemedicine, distance learning.)

   Security – big one! For medical data privacy and security.

   End to end transparency – for nomadic computing, and medical data privacy and security .

   Auto-configuration/neighbor discovery – easier/less costly to manage.

   Simplified headers – faster/more efficient processing of packets, (router works less.)

   Internet2/Abilene backbone – Offering native IPv6 services to their members:

   200 universities, 60 corporate partners, 11 government agencies, 17 international partners (as of 10/14/02.) [23]

The playground is there for "scientific collaboration."

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10. National Communications System (NCS) Technical Information Bulleting. (7/26/02) http://www.ncs.gov/n6/content/tibs/html/tib97_1/sec5_0.htm#sec5_2
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17. NTT Communications's IPv6 Activities. http://www.v6.ntt.net/globe/index-e.html

References (3)

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19. Mobility Support in IPv6. http://www.ietf.org/internet-drafts/draft-ietf-mobileip-ipv6-18.txt
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Acronyms

- ARPA – Advance Research Projects Agency
- CIDR – Classless Interdomain Routing
- IANA – Internet Assigned Numbers Authority
- IETF – Internet Engineering Task Force
- IPng – Internet Protocol Next Generation
- IPsec – Internet Protocol Security
- IPv4 – Internet Protocol Version 4
- IPv6 – Internet Protocol Version 6
- ISACA – Information Systems Audit and Control Association
- NAT – Network Address Translation
- NGI – Next Generation Internet
- NOC – Network Operations Center
- QoS – Quality of Service
- RFC – Request For Comments
- SRI – Stanford Research Institute

To Learn More – Web Sites

1. IPv6 - http://www.ipv6.org/
2. Testbed for deployment of IPv6 - http://www.6bone.net/
3. 6REN - IPv6 Research and Education Networks - http://www.6ren.net/
4. IP version 6 (IPv6) - http://playground.sun.com/pub/ipng/html/
5. IPv6 Forum - http://www.ipv6forum.com/
6. IPv6 Enabled Applications - http://www.ipv6.org/v6-apps.html

To Learn More - Articles/Papers

1. IPv6 White Paper.
http://www.cs-pv6.lancs.ac.uk/ipv6/documents/papers/BayNetworks/
2. Connecting IPv6 Routing Domains Over the IPv4 Internet
http://www.cisco.com/warp/public/759/ipj_3-1/ipj_3-1_routing.html
3. IPv6 –what's in it, and what's in it for you. (4/24/2002)
http://techupdate.zdnet.com/techupdate/stories/main/0,14179,2862374,00.html
4. IPv6: Ready when you are. (4/24/2002)
http://techupdate.zdnet.com/techupdate/stories/main/0,14179,2862388,00.html
5. Rocky road ahead for IPv6. (4/24/2002)
http://techupdate.zdnet.com/techupdate/stories/main/0,14179,2862401,00.html

Related RFCs

- RFC 2373 – IP version 6 Addressing Architecture
  http://www.faqs.org/rfcs/rfc2373.html
- RFC 2374 – An IPv6 Aggregatable Global Unicast Address Format
  http://www.faqs.org/rfcs/rfc2374.html
- RFC 2471 – IPv6 Testing Address Allocation
  http://www.faqs.org/rfcs/rfc2373.html
- RFC 2640 – Internet Protocol, Version 6 (IPv6) Specification
  http://www.faqs.org/rfcs/rfc2640.html

Thank You

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